Wabasha Street Bridge
Spanning the Mississippi River at Wabasha Street
City of St. Paul
Ramsey County
Minnesota

HAER No. MN-75

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Historic American Engineering Record
National Park Service
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Denver, Colorado 80225-0287

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HISTORIC AMERICAN ENGINEERING RECORD
WABASHA STREET BRIDGE

Location:	Spanning the Mississippi River at Wabasha Street St. Paul, Ramsey County, Minnesota
UTM:	North abutment: 15.492700.4976480 South abutment: 15.492860.4976170
Quad:	St. Paul East, Minnesota; 7.5 Minute Series
Date of Construction:	1888-1889 (north half); 1899-1900 (south half)
Present Owner:	City of St. Paul
Present Use:	Highway bridge; scheduled for demolition in 1995

Significance:

Spanning the Mississippi River in St. Paul, Minnesota, the Wabasha Street Bridge has played a major role in the development of the downtown business district and the city's "West Side." The structure is also the state's only surviving example of a nineteenth-century cantilevered truss highway bridge.

The St. Paul Bridge Company first constructed a toll bridge at this site in 1859. The crossing was intended to draw trade and travellers to St. Paul from the newly opened lands on the west side of the Mississippi, thus ensuring the city's future growth and prosperity. The City of St. Paul acquired ownership of the bridge in 1867. In 1874, the city removed the toll as part of an agreement whereby it annexed land on the west side of the river. The removal of the bridge toll in conjunction with other riverfront improvements led to the rapid growth of the west side lands. In 1888-1889, the city replaced the north half of the existing bridge with the current three-span, cantilevered steel structure. Andreas W. Munster, Chief Bridge Engineer for St. Paul, designed this section of the bridge as a continuous structure in order to facilitate construction. Following standard practice, he broke-up the continuity of the superstructure by inserting hinge points, thus creating cantilever spans. Horace E. Horton, later founder of the Chicago Bridge and Iron Company, erected the structure. In 1899-1900, St. Paul replaced the south half of the bridge with simple steel, pin-connected Pratt deck trusses, also designed by Munster.

Historians: Demian J. Hess and Jeffrey A. Hess, December 1993

Description

Located in St. Paul, Minnesota, the Wabasha Street Bridge crosses the Mississippi River on a nearly north-south line, linking the central business district, on the north, with the city's so-called "West Side," on the south (see HAER Photo No. MN-75-1). The bridge has a total length of approximately 1,200 feet. The northern half is composed of a three-span, steel, cantilevered structure built in 1888-1889 (see HAER Photo No. MN-75-9). From north to south, this section consists of a 65-foot suspended span attached to a 60-foot cantilever arm, a 280-foot continuous truss, a 40-foot cantilever arm, and a 150-foot suspended span. Measured from bearing point to bearing point, these components form three clear spans of 125 feet, 280 feet, and 190 feet. With the exception of the first suspended span, which is rivetted, all truss connections in the northern half of the bridge are pinned. The southern half of the bridge was built in 1899-1900. It consists of three 170-foot, steel, pin-connected, Pratt deck trusses, and one 78-foot, steel-girder approach span. The bridge carries a 40-foot-wide concrete roadway throughout, flanked by 8-foot-wide sidewalks.

The superstructure of the Wabasha Street Bridge is supported by two sandstone abutments and six piers. The second and fifth piers are located in the river channel, while the first and sixth stand on the river banks. The third and fourth piers are sited on an island in the middle of the Mississippi. The river channel piers are solid stone with granite icebreakers. The remainder are two-legged, stone piers with steel bents.

The current structure is the latest in a long line of bridges that have crossed the Mississippi at this site. The construction -- and reconstruction -- of these bridges is so closely tied to the development of St. Paul that any history of the Wabasha Street crossing must begin with the founding and early growth of the city.

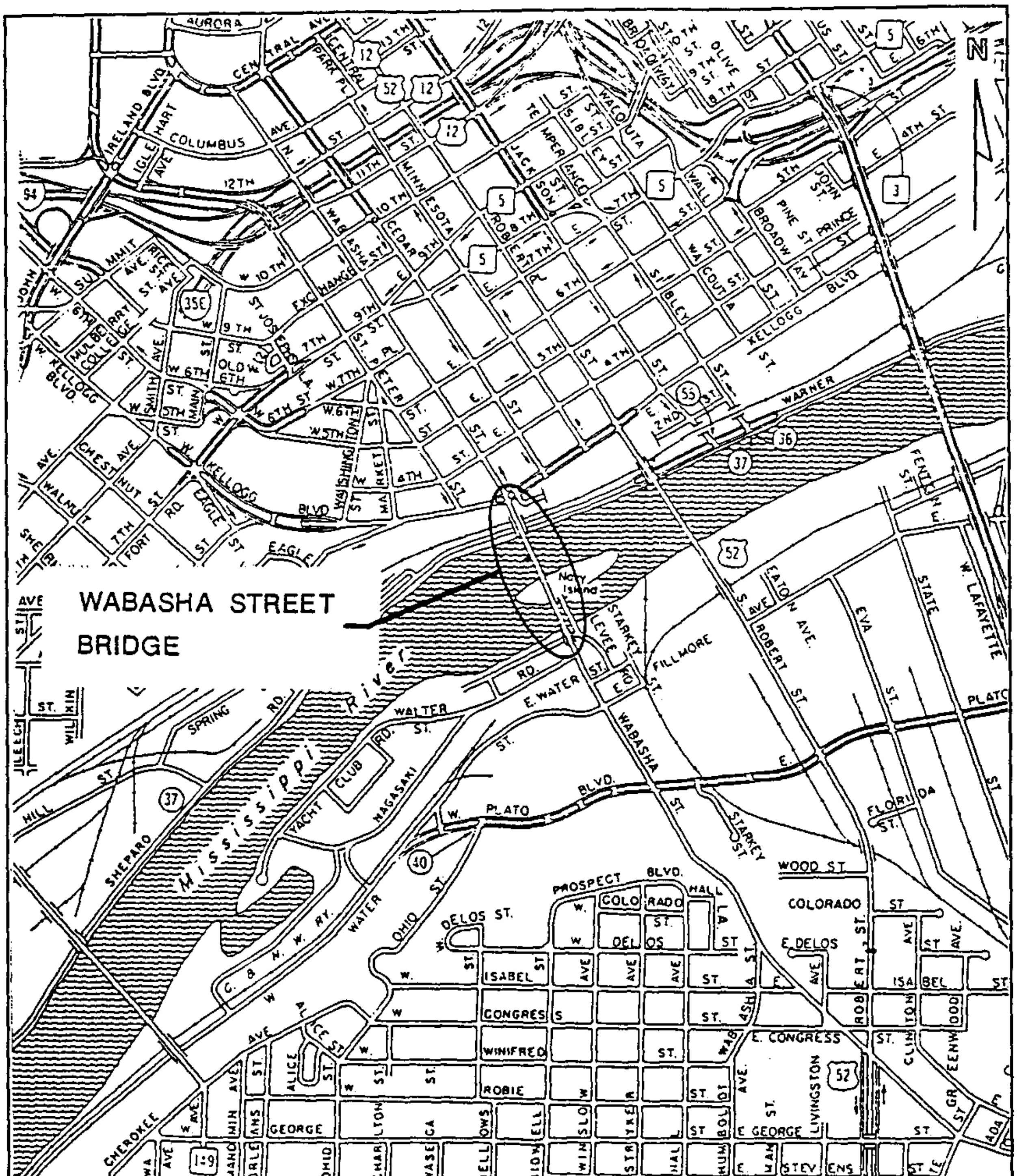

Figure 1: Locational Map of the Wabasha Street Bridge

Founding and Growth of St. Paul

In 1819, the U.S. Army established a fort on the west side of the Mississippi River at its confluence with the Minnesota River. The army post, later known as Fort Snelling, was part of a larger military reserve, created through negotiations with the Native American tribes inhabiting the region. This tract was intended for military use only, but settlers quickly took claims on it. The army suffered this trespass in silence until 1838, when it finally resurveyed the reservation boundaries and expelled the squatters. The dislocation did not render the settlers landless, for in the same year Congress ratified treaties with the area's Ojibwa and Dakota Indians that opened the entire region between the Mississippi and St. Croix rivers to development. Joined by other land seekers, the squatters moved approximately four miles downstream and founded a new community, initially known as "Pig's Eye" in honor of a local trader, but later rechristened St. Paul.[1] The original settlement stood on what is traditionally known as the east bank of the Mississippi, although in terms of compass orientation it actually is the north bank, the river flowing east-west at this particular location.

The community proved to be well sited. Its close proximity to the military reserve gave it a measure of protection, and for all practical purposes, it lay at the head of navigation on the Mississippi River. St. Anthony Falls, located approximately thirteen miles upstream, barred travel further north, while the river between the falls and St. Paul was too rocky and shallow for safe navigation. Steamships plying the river made St. Paul their northern terminus, landing at a low bench of land called the "Lower Levee" at the foot of bluffs lining the east shore. A business district developed on top of the bluffs, connected to the Lower Levee by a cartway that

[1] William Watts Folwell, A History of Minnesota, vol. 1 (St. Paul: Minnesota Historical Society, 1956), 135-138, 215-225.

followed a natural ravine. When Minnesota Territory organized in 1849, St. Paul became the seat of government. Incorporated in the same year, the new city boasted a population of 1,294, nearly a quarter of the territory's inhabitants.[2]

In 1851, the federal government concluded negotiations with the Dakota Indians to open Minnesota Territory west of the Mississippi to settlement. Newcomers immediately rushed into the area and contributed substantially to St. Paul's growth. Located at the head of the Mississippi, the city became the gateway for immigration and the region's major trade center. The number of steamboats landing in St. Paul rose from 194 in 1850, to 300 in 1854. In 1855, the number reached 560. Population also swelled, totalling 4,716 in 1855. When Minnesota achieved statehood in 1858, St. Paul continued as its capital.[3]

Although the opening of the west side lands brought growth and prosperity to St. Paul, it also brought challenges. New towns sprang into being on the opposite side of the river and rivaled St. Paul for the area's trade. Minneapolis, located a few miles upstream of St. Paul on the Mississippi, became a major sawmilling center in the mid-1850s, due to its proximity to St. Anthony Falls. Because of the difficulty of navigating the river above St. Paul, however, Minneapolis initially presented only a minor challenge as a center of trade. A more significant adversary proved to be Hastings, located approximately 20 miles downstream on the west side of the Mississippi. Settlers in southern Minnesota preferred to haul their wagons directly to

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[2] Edward D. Neill, History of Ramsey County and the City of St. Paul (Minneapolis: North Star Publishing Company, 1881), 311.

[3] Neill, 305, 318; J.E. Land, Historical and Descriptive Review of the Industries of St. Paul, 1882-1883 (St. Paul: n.p., 1883), 10-16.

market at Hastings rather than take a ferry across the river to reach St. Paul.[4]

A bridge was obviously necessary to link St. Paul firmly to the west side lands. James M. Goodhue, editor of St. Paul's Minnesota Pioneer, took "up the cudgel to obtain a bridge" as early as 1849. Goodhue advocated locating the crossing just above, or west of, the Lower Levee, where a small island lay in the river channel. The island could serve as a stepping stone for the bridge, reducing the expense of building piers in the river. A high stone bluff towered over the Mississippi on the east shore, and Goodhue envisioned the bridge descending gradually from the bluff toward the west side river flats, high above the level of steamboat traffic. Due to the river's course, the bridge would run on a north-south line, the north end lying on the east shore and the south end being connected to the west shore.[5]

City officials and entrepreneurs did not immediately respond to Goodhue's call. Building a bridge was an expensive undertaking, and few cared to bear the cost. With the opening of the west side of the river and the development of trade with the interior, however, many began to realize the business potential of operating toll bridges. In 1852, the territorial legislature charted its first toll bridge company to span the Mississippi at Minneapolis. The government chartered three more companies in 1853, including one to construct a crossing at St. Paul.[6]

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[4] Newspapers commented frequently on the dangers posed by other towns to St. Paul's trade with the interior. See the following for examples: "The St. Paul Bridge," St. Paul Daily Minnesotian, 20 July 1857, 2:1; "St. Paul and its Communications," Pioneer Democrat Weekly, 29 July 1858, 6:2.

[5] Minnesota Pioneer, 26 July 1849, quoted in J. Fletcher Williams, A History of the City of St. Paul to 1875 (St. Paul: Minnesota Historical Society, 1876; repr. 1983), 230; Minnesota Pioneer, 28 July 1849, 2:2.

[6] Arthur J. Larsen, "The Development of the Minnesota Road System," Typewritten manuscript, 1966, Minnesota Historical Society, St. Paul, Minnesota, 132-135, 143-149.

St. Paul Bridge Company

The Minnesota Territorial Legislature granted the St. Paul Bridge Company a 35-year franchise to bridge the Mississippi in the location of St. Paul. The government required construction to begin by March 1856, and all work to be completed within five years. Failure to start or finish the bridge within the time allowed would result in the loss of the franchise.[7]

Many of St. Paul's most prominent citizens were founding members of the enterprise, including William R. Marshall, who served as the company's president and was later the state's fifth governor; Lyman Dayton; Auguste L. Larpenteur; Louis Robert; John R. Irvine; and William Gates LeDuc. LeDuc's involvement in the bridge company was something of a hedge, for he was also a heavy investor in Hastings real estate.[8]

Despite its distinguished list of founders, the company failed to attract investors and could not begin construction on time. In March 1856, the legislature granted an extension, moving the deadline back to 1 July 1857. Even with the extra time, however, the St. Paul Bridge Company only managed to raise $49,237 in stock subscriptions.[9] Although the amount was clearly not enough to build the bridge, the company could not delay any longer. During the summer of 1856 it proceeded with its plans. In June, it secured Joseph S. Sewall to serve as the chief engineer for the project. A resident of St. Paul since 1854, Sewall prepared many of

[7] Josiah B. Chaney, "Early Bridges and Changes of the Land and Water Surface in the City of St. Paul," Collections of the Minnesota Historical Society 12 (December 1908): 131-148.

[8] Chaney, "Early Bridges," 132; "William Gates LeDuc," Minnesota History Bulletin 3 (May 1919): 60-61.

[9] Chaney, "Early Bridges." The difficulty of raising stock subscriptions is referred to obliquely in "The St. Paul Bridge," St. Paul Daily Minnesotian, 20 July 1857, 2:1. For the exact amount raised in subscriptions refer to the following: Petition of the St. Paul Bridge Company Stockholders to the City Council, 23 August 1866, St. Paul City Council, Miscellaneous Records, Minnesota State Archives, Minnesota Historical Society, St. Paul (material from this collection will hereafter be referred to as "St. Paul City Council Miscellaneous Records").

the early city plats and would eventually supervise the construction of at least two other Mississippi River bridges in the St. Paul area: the steel, cantilevered, deck-truss Fort Snelling Highway Bridge (1880) and the steel-arch Marshall Avenue Bridge (1889). To construct the crossing's substructure, the company selected the local firms of J. and J. Napier and Sanford A. Hooper. A St. Paul contractor named Rudolph H. Fitz appears to have erected the superstructure.[10]

As suggested by Goodhue, the St. Paul Bridge Company planned to bridge the Mississippi on a north-south line where a small landmass called Navy Island (at that time known as Raspberry Island) divided the river into two channels. Since the section between the island and the west shore was too shallow for navigation, river traffic was confined to the east shore side. This passage, generally referred to as the "main channel," measured approximately 360 feet in width. The bridge company planned to place two stone piers in the main channel, the first to be 20 feet and the second to be 240 feet from the east bank. The contractors began work by building the second pier, sinking pilings and placing stone during the winter of 1856-1857.[11]

The St. Paul City Council raised objections to the placement of the piers in January 1857, and brought suit against the St. Paul Bridge Company in March to halt all construction. The Council argued that if the company completed the piers as planned, it would seriously obstruct navigation by narrowing the main channel to 220 feet. This violated the company's charter, which specified that the bridge would allow a clear opening of at least 300 feet. The bridge

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[10] "Pioneer Engineer Dies at Age of 91," St. Paul Daily News, 22 December 1917, 2:7; "J.S. Sewall, St. Paul Pioneer, Is Dead," Minneapolis Journal, 23 December 1917, 6:1; Williams, History of the City of St. Paul, 368; Inventory sheet biographical sketch of Rudolph H. Fitz, Fitz Papers, Minnesota State Archives, Minnesota Historical Society, St. Paul, Minnesota.

[11] Answer to complaint, City of St. Paul v. St. Paul Bridge Company, case number 1784, 11 March 1857, Ramsey County District Court, Minnesota State Archives, Minnesota Historical Society, St. Paul.

company admitted that it had not conformed to the letter of its charter, but denied that the bridge piers would inconvenience river traffic. After negotiations, the company eventually agreed to increase the channel width to 240 feet. Because the second pier had already been started and could not be moved, the additional clearance was obtained by building the first pier on the east shore, out of the main channel. Mollified by the compromise, the city dropped its suit in April.[12]

Work on the bridge piers continued through 1857, although hampered by high water during the spring. New problems appeared in September, however, when the contractors refused to continue construction until they received payment for work performed to date. The bridge company could not meet these demands because it had not succeeded in disposing of all its stock. In desperation, it petitioned its recent adversary, the City Council, to purchase its remaining subscriptions, amounting to slightly more than $100,000. The city agreed and issued bonds to cover the cost, receiving assurances from the company that projected toll revenues would be sufficient to cover the interest "so that the taxation of the city shall not be increased."[13]

The influx of money allowed the St. Paul Bridge Company to press construction to completion without further incident. Originally called the "St. Paul Bridge" but later renamed the "Wabasha Street Bridge," the structure opened to traffic in June 1859. The bridge began

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[12] Answer to complaint, City of St. Paul v. St. Paul Bridge Company, 11 March 1857. Refer to the following entries in St. Paul City Council Minutes, volume for 1854-1858, held in St. Paul City Council, Minutes, Minnesota State Archives, Minnesota Historical Society, St. Paul (collection hereafter referred to as "St. Paul City Council Minutes"): 20 January 1857, 377; 3 February 1857, 382-383; 23 March 1857, 401; 31 March 1857, 405; 14 April 1857, 414.

[13] "The St. Paul Bridge," St. Paul Daily Minnesotian; Chaney, "Early Bridges," 133-134; refer to the following entries in St. Paul City Council Minutes, volume for 1854-1858: 1 September 1857, 511-512; 3 September 1857, 516-517.

at Wabasha Street at the edge of the business district and then ran southward to cross the river in nine spans, slowly descending from the height of the east side bluffs to the level of the west side river flats. All of the spans were carried by stone piers measuring 7 by 30 feet at the top. The east shore abutment at the north end of the bridge consisted of a low bench cut into the river bluff, while a stone abutment supported by piles stood on the opposite shore. The first pier, as agreed, stood at the very edge of the east shore, partially resting on the native rock of the bluff and partially supported on wooden piles. The second and third piers were located in the main navigation channel, the second being 240 feet from the east bank, and the third standing near Navy Island. The fourth and fifth piers were built on the island proper, while the remainder stood in the shallow water of the far channel. The superstructure, from north to south, consisted of one 100-foot span, one 240-foot span, and seven 140-foot spans. With the exception of the main channel span, all were wooden Howe deck trusses. The main span was a wooden Howe through truss. The crossing also included an approach on the west shore river flats consisting of a 50-foot timber stringer span and a 330-foot timber trestle. The bridge appears to have supported an 18-foot-wide roadway flanked by 7-foot-wide sidewalks.[14]

Although the St. Paul Bridge Company legally owned the Wabasha Street Bridge, the City of St. Paul appears to have had practical control over its operations. The city had contributed $114,870 to the bridge's total cost of $161,855. By virtue of this substantial investment, it claimed all toll revenues to repay the cost of its bonds, and also exercised substantial power over

[14] J.H. Grindall to Bridge Committee, 5 September 1872, St. Paul City Council Miscellaneous Records; F.B. Malthy, "Historical and Descriptive Sketch of the Bridges over the Mississippi River," Journal of the Western Society of Engineers 8 (1903): 434-436. Maltby incorrectly identifies the first span as only having a length of 80 feet.

toll rates. When a group petitioned to waive tolls for State Fair exhibitors in 1862, it addressed itself directly to the City Council and not the bridge company.[15]

Even the St. Paul Bridge Company's nominal command of the bridge eventually ended, largely due to the venture's unprofitability. Despite the fact that many other toll bridges were enjoying high returns, especially the crossing at Minneapolis, the Wabasha Street Bridge suffered from low traffic and disappointing profits for many years. By August 1866, revenues totalled only $31,219.94. By contrast, total accrued interest on the city's bonds during the same time period amounted to $89,019.90. Unhappy that revenues were not repaying interest on bonds as promised, city authorities entered into negotiations with the bridge company in August 1866 to take over the bridge. Owning the crossing would obviously give the city more direct control over its operations and possibly reduce expenses, allowing more revenue to go toward bond payments. In March 1867, the company finally turned the bridge over to St. Paul in exchange for one-third the face value of its stock.[16]

Wabasha Street Bridge Under the City of St. Paul

St. Paul continued to operate the Wabasha Street Bridge as a toll crossing to recover as much of the cost of construction and maintenance as it could. While returns were never high enough to cover all expenses, they did rise after the city's takeover of the crossing, largely as the result of increasing traffic. Whereas bridge receipts had averaged only $5,000 per year

[15] Costs are drawn from "Report of Bridge Committee," c.1866, St. Paul City Council Miscellaneous Records. Also see Petition to the City Council, 5 August 1862, St. Paul City Council Miscellaneous Records.

[16] Bridge returns are reported in "Report of Bridge Committee," c.1866; William R. Marshall to City Council, 3 August 1866, St. Paul City Council Miscellaneous Records; Petition of Stockholders of the St. Paul Bridge Company to the City Council, 23 August 1866; Chaney, "Early Bridges," 134.

between 1859 and 1866, they reached a total of more than $10,000 per year during the late 1860s and early 1870s.[17] St. Paul owed the rise in bridge traffic, at least in part, to the construction of railroads into the city beginning in 1862. The rail lines tied St. Paul even more firmly to the interior markets to the west and the industrialized cities to the east, leading to greater economic development and higher levels of highway traffic between the city and the surrounding countryside.

As traffic over the Wabasha Street Bridge increased, so too did pressure to make it a toll-free crossing. St. Paul business leaders and newspaper editorialists had argued from the outset that bridge tolls discouraged travel into the city to the detriment of the economy. Another group opposed to tolls proved to be West St. Paul Township residents, who were located in Dakota County immediately across the river from the city. Due to their proximity, these people used the bridge more frequently than any other group and felt the burden of tolls most keenly.[18]

Despite numerous requests and criticisms, St. Paul did not remove the toll for several years. The main obstacle was cost. Maintaining the bridge proved to be expensive, and no group was willing to help defray the cost if tolls were lifted -- putting all of the burden on municipal coffers. In 1871, for example, in response to a petition from Dakota County, St. Paul agreed to make the bridge a free crossing if the county would pay one-third of the maintenance.

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[17] Returns from 1859 to 1866 are based on "Report of Bridge Committee," c.1866. Returns for the years after 1868 based on "Bridge Receiver Reports," 1863, 1866, 1872-1874, St. Paul City Council Miscellaneous Records, Box 5; also see St. Paul Daily Press, 21 April 1869, 4:1.

[18] "St. Paul Bridge Celebration," Weekly Pioneer and Democrat, 2 June 1859, 8:1. The dependence of Dakota County residents on the Wabasha Street Bridge is highlighted by a petition submitted by West St. Paul residents to the City Council, in which they state: "We your humble petitioners use the Bridge more, and are more dependent upon it than residents of your city, [and so] the [Toll] Receiver becomes more an officer placed over us, than an officer of the city, and we become greatly dependant upon him" ("Petition," 29 December 1873, St. Paul City Council Miscellaneous Records). Also see Minneapolis Daily Tribune, 22 April 1871, 4.

Dakota County taxpayers balked at this stipulation, however, leaving the matter at an impasse.[19]

The deadlock over the bridge eventually broke in 1874. In April of that year, a special committee reported to the St. Paul Common Council that "the subject of making the bridge over the river free to all is now under advisement, and will end, probably, in making said bridge free."[20] By this time, the status of the bridge had become entangled in a plan for St. Paul to annex part of Dakota County lying immediately opposite the city on the west shore of the Mississippi. The area included all of the land between the river and the south line of Sections 7, 8, and 9 of Township 28, Range 22, comprising a parcel of approximately 2,800 acres.

This territory had been platted as the townsite of West St. Paul in 1856, and the legislature granted it a corporate charter in 1858. William Gates LeDuc, a founder of the St. Paul Bridge Company, owned land within the townsite and was a leading figure in its organization. The fortunes of West St. Paul were closely tied to the bridge, for its proximity to that structure and downtown St. Paul were its primary attractions. The new city, however, did not prove to be as popular as its promoters had hoped. While a modestly sized community did grow, totalling 662 residents by 1860, it did not develop a substantial tax base. As a result, the city repeatedly failed to meet its bond payments. In 1862 the state legislature revoked West St. Paul's charter. The surrounding township, also named West St. Paul, absorbed the former city's territory.[21]

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[19] Minneapolis Daily Tribune, 22 April 1871, 4.

[20] 21 April 1874, volume for March to December 1874, St. Paul City Council Minutes, 24.

[21] Information on the platting of West St. Paul was provided by Chuck Dercheiz, Dakota County Recorder's Office, during a telephone interview with Demian J. Hess, 20 July 1993; see also "William Gates LeDuc," Minnesota History Bulletin; Neill, History of Ramsey County, 330-332.

St. Paul's interest in the City of West St. Paul reportedly stemmed from its concern over law enforcement. The area lay outside the jurisdiction of St. Paul police, so that criminals often evaded apprehension simply by crossing the Wabasha Street Bridge. By annexing the land, the city hoped to bring law and order to the wild west side of the Mississippi. One obstacle to the plan was the fact that St. Paul lay in Ramsey County while the old City of West St. Paul was in Dakota County. For the territory to become part of St. Paul, it first had to be transferred to Ramsey County. The change in jurisdiction required the approval of Dakota County voters, who did not look with favor on the loss of such a large tract of land. To woo voter support, St. Paul offered to make the Wabasha Street Bridge a free crossing if it could annex the parcel.[22]

St. Paul also had another motive for trading its toll revenues for the West St. Paul territory. Industrial sites which were adjacent to downtown and had access to rail and river connections were becoming increasingly scarce on the east side of the Mississippi in the 1870s. The west side river flats, by contrast, were undeveloped and obviously had tremendous industrial potential. By acquiring the west side lands, the City Council hoped to assure St. Paul's future industrial and manufacturing growth.[23]

St. Paul's offer of a free bridge evidently satisfied Dakota County residents. On 3 November 1874, voters in both Ramsey and Dakota counties overwhelmingly approved the proposition to transfer Old West St. Paul to Ramsey County. The St. Paul Daily Pioneer did not even bother reporting the election returns the next day "as the vote was so nearly unanimous

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[22] Neill, History of Ramsey County, 333-334.

[23] The desirability of the West St. Paul lands is extensively treated in "West St. Paul," Northwest Magazine, 4, 11 (November 1886): 10-24.

that it is unnecessary. There were not thirty votes cast against it."[24] The former City of West St. Paul thus became the Sixth Ward of the City of St. Paul, although it was still commonly called "West St. Paul." In keeping with its promise, the City Council declared that the Wabasha Street Bridge would be free to all beginning at noon on 18 November 1874.

The removal of the bridge toll lifted a major psychological and economic barrier that had long separated St. Paul from the west side of the river. West St. Paul, which formerly had seemed remote, increasingly beckoned as an attractive residential and commercial area. Between 1875 and 1880, the population of the Sixth Ward more than doubled to 2,688 people. Many of the new residents settled in the "Lower West Side," a neighborhood that stretched across the flood plain from the foot of the bluffs to the river shore. Prone to flooding, the land was inexpensive and primarily attracted recent immigrants from Ireland or Germany with limited means. After 1882, the ethnic composition became increasingly dominated by Eastern European Jews.[25] A commercial district also developed along South Wabasha Street (then called Dakota Avenue) at the south end of the bridge. In the heart of the growing West Side neighborhood, yet close to downtown, this area was ideal for shops and offices, and it contained over 20 brick retail buildings by 1885.[26]

As many had foreseen, the West Side proved to be a congenial location for manufacturers, especially after the city began constructing a flood wall along the river front in the 1880s. Industrial growth was further encouraged by the Minnesota and Northwestern Railroad, which

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[24] "The Election Yesterday," St. Paul Daily Pioneer, 4 November 1874.

[25] See the Minnesota State Census for 1875 and 1880; microfilm copy held by the Minnesota Historical Society, St. Paul, Minnesota; Lorraine E. Pierce, "St. Paul's Lower West Side," Master's thesis, University of Minnesota, 1971, 3-44.

[26] "West St. Paul," Northwest Magazine, 11.

built a bridge over the Mississippi in 1886 to introduce rail service to the area. Concurrent with this project, the company graded a large tract of land to the east of the Wabasha Street Bridge. Due to these improvements, a large number of manufactories located along the west shore, including, to either side of the Wabasha Street Bridge, the Twin City Fence and Wire Works and the St. Paul Roofing and Cornice Company.[27]

The rise in traffic over the Wabasha Street Bridge from the mid-1860s to the 1880s created constant maintenance problems for the City of St. Paul. The St. Paul Bridge Company had originally built the crossing out of wood in order to reduce cost. The wooden members quickly deteriorated due to wear and weather. The through truss over the main navigation channel, as the longest span, proved to be most susceptible. In 1869, the City Council contracted with William P. Farrell, a St. Paul builder, to replace the 240-foot wood span with a combination wood-and-iron Howe through truss. Specifications for the new span were prepared by Judson W. Bishop, engineer for the St. Paul and Sioux City Railroad. M.T. Thomas, a local engineer, supervised construction. Farrell completed the span by March 1870.[28]

While inspecting the new through truss, a committee of engineers took the time also to examine the rest of the Wabasha Street Bridge. In the spring of 1870, they reported that all of

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[27] "West St. Paul," Northwest Magazine, 10-11; Chaney, "Early Bridges," 139; St. Paul, Minnesota, vol. 5 (New York: Sanborn Map Company, 1903), 602.

[28] 28 October 1869, volume for 1866 to 1870, St. Paul City Council Minutes, 490. Also see the following correspondence in St. Paul City Council Miscellaneous Records: Committee on Bridges to the Common Council, 7 December 1869; M.T. Thomas to Bridge Committee, 11 December 1869, 11 and 17 March 1870; J.W. Bishop, F.R. Desiro[?], and J.S. Sewall to Common Council, 11 March 1870.

the wooden deck trusses were in poor condition and needed to be replaced.[29] Although city authorities were initially reluctant to shoulder this additional expenses, they finally decided in the winter of 1871-1872 to contract with George W. Sherwood of St. Paul to carry out the necessary repairs. Using the original plans and specifications for the bridge, Sherwood rebuilt all of the deck trusses as well as the approach trestle on the south end.[30]

The repairs to the main span lasted only until 1875, at which time the city once again faced the task of rebuilding. Convinced that wooden members would continue wearing out too quickly, the city decided to replace the main span with a wrought-iron Whipple through truss. L.W. Wellman, the City Engineer, and Joseph S. Sewall, consulting engineer, prepared specifications for the truss and reviewed all bids received. On 8 December 1875, the City Council awarded the contract to a Milwaukee bridge builder named L. Soulerin for $20,160. Soulerin completed construction by the next spring, and on 20 July 1876 the special committee appointed to inspect the work reported that "we are satisfied that the city has got a 240 foot span of Iron Bridge that is not surpassed by anything in the North West".[31]

[29] See the following correspondence in St. Paul City Council Miscellaneous Records: William Lee to Common Council, 18 April 1870; J.S. Sewall to William Lee, 3 May 1870; J.S. Sewall and J.H. Gundall to William Lee, 3 May 1870.

[30] G.W. Sherwood to Bridge Committee, 5 September 1872, St. Paul City Council Miscellaneous Records; Contract with George W. Sherwood, 19 October 1872, St. Paul City Council, Contracts and Leases, Box 1, Minnesota State Archives, Minnesota Historical Society, St. Paul, Minnesota (collection hereafter referred to as "St. Paul City Council Contracts and Leases").

[31] The quoted passage is from J.A. Reaney and L.W. Wellman to City Council, 6 April 1875. For the construction history of the wrought-iron span, see the following entries in the volume for 1874 to 1877, St. Paul City Council Minutes: 6 October 1875, 354; 19 October 1875, 366; 4 December 1875, 382; 8 December 1875, 398. Also refer to the following correspondence in St. Paul City Council Miscellaneous Records: Charles W.F. Morris to Bridge Committee, 5 February 1875; J.W. Bishop to Bridge Committee, 6 February 1875; L.W. Wellman to Bridge Committee, 6 February 1875; I.B.Fish to Bridge Committee, 10 February 1875; J.S. Sewall to Bridge Committee, 12 February 1875; "Report of Special Bridge Committee of the Chamber of Commerce and the City

Although the main truss members were constructed of iron, the bridge deck was still wood, as were all members of the remaining spans. These components of the bridge continued to wear rapidly, particularly as traffic surged over the bridge following the removal of the toll. In 1880, the St. Paul Common Council, successor to the City Council, received a letter from one concerned citizen questioning whether the Wabasha Street Bridge was safe.[32] The following year a group of St. Paul residents submitted a petition decrying the crossing's "rotten, dilapidated condition."[33] Besides requesting the repair of the existing crossing, the petitioners also urged the city to construct additional bridges over the Mississippi. The Common Council's Committee on Roads and Bridges was of similar mind. In 1880, it recommended that the Wabasha Street Bridge be repaired and observed that "St. Paul can never utilize the large and valuable territory on that [west] side of the river without at least three more bridges."[34]

In 1881, St. Paul secured permission from the state legislature to construct a new bridge over the river at Robert Street, just east of the Wabasha Street Bridge. Completed in 1886, this structure connected the downtown business area to the river flats and became the main link to the West Side. The city began a third bridge in 1887, locating it west of the Wabasha Street Bridge at Smith Street. Generally known as the "High Bridge," the structure connected St. Paul with the bluffs on the west side of the river.[35]

Council," [1875]; Bridge Committee to Common Council, 20 July 1876.

[32] James Starkey to the St. Paul Chamber of Commerce, 16 February 1880, St. Paul City Council Miscellaneous Records.

[33] Petition to the Common Council, 29 September 1881, St. Paul City Council Miscellaneous Records.

[34] Report of the Committee of Roads and Bridges, 6 April 1880, St. Paul City Council Miscellaneous Records.

[35] Maltby, "The Mississippi River Bridges," 433-434, 437-438.

While the city constructed new bridges, it also turned its attention to repairing and upgrading the Wabasha Street Bridge. In 1883, St. Paul contracted with the Missouri Valley Bridge Company of Leavenworth, Kansas, to replace the bridge's third, fourth, and fifth spans with 140-foot wrought-iron Pratt trusses. At the same time, Horace E. Horton, a bridge builder from Rochester, Minnesota, received a contract to replace the sixth span with a 140-foot wrought-iron Pratt truss. All of this work appears to have been completed before the end of 1883.[36]

In 1884, Missouri Valley Bridge received another contract to replace the first, seventh, eighth, and ninth spans with wrought iron trusses. The seventh and eighth spans remained 140-feet in length, but the ninth was shortened to 110 feet and the first to 90 feet. Missouri Valley Bridge also replaced the long trestle on the west shore with two wrought-iron Pratt through trusses, each measuring 115 feet in length. For the installation of the spans, the bridge company constructed new abutments and piers. Work under this contract appears to have been completed by the spring of 1885.[37]

Despite the extensive rebuilding program, the Wabasha Street Bridge continued to be a source of concern. In February 1888, L.W. Rundlett, the City Engineer at that time, warned the St. Paul mayor that the bridge's 240-foot, wrought-iron main span, erected in 1870, was in

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[36] Maltby, "The Mississippi River Bridges," 434-437; M.S. Grytbak, "Memo of Wabasha Street Bridge History," 19 November 1921, Correspondence Files, Bridge Division, Department of Public Works, City of St. Paul, Minnesota (collection hereafter referred to as "St. Paul Public Works Correspondence Files"); Idem, "Wabasha St. Bridge, Formerly St. Paul Bridge," 1919, St. Paul Public Works Correspondence Files; Contract with Horace E. Horton, 24 February 1883, St. Paul City Council Contracts and Leases.

[37] Maltby, "The Mississippi River Bridges"; Grytbak, "Memo"; Idem, "Wabasha Street Bridge, Formerly St. Paul Bridge"; Contract with M.H. Insley, D. Shire, and A.J. Tullock, 22 July 1884, St. Paul City Council Contracts and Leases. The contract specified that the through trusses and the ninth span were to be 115 feet long. Although the lengths of these spans have been variously reported, the figures reported in the text appear to be the actual as-built dimensions.

imminent danger of failure. The problem, Rundlett observed, was that the truss had been built at a time "when the requirements of iron bridges were not as well understood as they are at the present time."[38] Rundlett had alerted the Common Council to structural deficiencies in the main spain as early as 1883, when he reported that the truss members were unevenly stressed.[39] Five years later, he believed that the situation could no longer be ignored, and he urged the city to immediately place load restrictions on the structure. The Common Council adopted Rundlett's advice and authorized him to prepare plans to repair the main truss. Although ostensibly an effort to replace only one span, the project quickly blossomed into the first phase of a major redesign of the entire bridge.

Reconstruction, 1888-1900

Rundlett initially planned to rebuild the main span to the dimensions of the existing bridge, namely with an 18-foot-wide roadway and two 7-foot-wide sidewalks. In February 1888, however, he was approached by a citizens' committee from the West Side and by a delegation from the St. Paul Chamber of Commerce urging him to widen the span to accommodate increased traffic levels. Both groups hoped that the rest of the bridge would soon be widened as well.[40]

Rundlett sympathized with the request, and on 8 March 1888, he submitted two proposals to the Common Council to rebuild the north end of the bridge to carry a 36-foot-wide roadway

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[38] L.W. Rundlett to Robert A. Smith, 7 February 1888, volume for 1888, St. Paul City Council Minutes, 41.

[39] "Memorandum about the 240' Span, Wabasha Street Bridge," August 1882, St. Paul Public Works Correspondence Files.

[40] 8 March 1888, volume for 1888, St. Paul City Council Minutes, 70-72.

and two 10-foot-wide sidewalks. Rundlett observed that the old bridge piers would need to be taken down and replaced to accommodate such a widened span, as "it is much more difficult to design a new structure to fit old work and get economical results than it is to design entirely new work."[41] According to his first scheme, Rundlett proposed replacing the bridge from its north abutment to the end of the main channel span. A second option was to rebuild the bridge to the end of the fourth span on Navy Island. On 20 March, the Common Council authorized Rundlett to prepare plans and specifications according to the second option.[42]

The task of designing the new north half of the Wabasha Street Bridge fell to Andreas Wendelbo Munster, head of the Public Works Department's Bridge Division. Born in Bergen, Norway, and educated at the Chalmers Institute in Gothenburg, Sweden, Munster had emigrated to the United States in 1883, arriving in St. Paul in 1884. In his short time working for the city, Munster had already designed the wrought-iron truss Sixth Street Viaduct (1887), as well as the Colorado Street Bridge (1888), a skewed stone and brick arch that attracted national attention for its unorthodox design. In later years, Munster would establish a well-respected engineering consulting practice in the Pacific Northwest, and at the time of his death in 1929, he was serving as the City Engineer for Seattle.[43]

Munster decided to replace the four northern spans with a three-span structure, thus reducing the expense of construction by eliminating one pier (see HAER Photo No. MN-75-32).

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[41] Ibid.

[42] 20 March 1888, volume for 1888, St. Paul City Council Minutes, 110.

[43] For biographical information on Munster, see Kenneth Bjork, Saga in Steel and Concrete (Northfield, Minnesota: Norwegian-American Historical Association, 1947), 141, 145, 155-157. On the Colorado Street Bridge, see "Colorado Street (St. Paul) Skew Arch Bridge," Engineering and Building Record 20 (November 23, 1889): 365-366; Jeffrey A. Hess, National Register of Historic Places Registration Form for the Colorado Street Bridge, 1988, State Historic Preservation Office, Minnesota Historical Society.

His design for these spans was largely dictated by several unusual site conditions. The primary issue was the need to keep the main river channel open for navigation. While Munster could build the first and third spans on falsework, he could not block the main section of the river to erect the second, and longest, span. Munster partially overcame this problem by assembling the central portion of the second span on the deck of the old bridge. The old wrought-iron truss, however, could not carry the full weight of the new work. Munster therefore decided to build the ends of the second span by the cantilever method. According to this scheme, workmen built from the piers at the ends of the main span toward the center without using any falsework. For support, each end of the span hung from its respective pier, anchored by the weight of the adjacent truss. Once the ends and center were built, all three sections could be attached and the old truss removed.[44]

Although British engineers had suggested using the cantilever method to erect bridges as early as 1846, the technique apparently was not attempted until the 1870s, despite several proposals along these lines in the intervening years. Early projects built by the cantilever method included James B. Eades's bridge over the Mississippi at St. Louis, begun in 1873, and the Kentucky River High Bridge near Dixville, Kentucky, completed in 1877. After the success of these bridges, the technique was widely accepted and employed in the 1880s.[45]

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[44] For the construction of the north half of the Wabasha Street Bridge, refer to "Erection of the Wabasha Street Bridge, St. Paul, Minn., Part I," Engineering Record 25 (26 December 1891): 58-59; "Erection of the Wabasha Street Bridge, St. Paul, Minn., Part II," Engineering Record 25 (16 January 1892): 108. The first of these articles is reproduced on pages 33-34 of this study.

[45] For a discussion of the cantilever erection method and some of the earliest bridges built by this technique, refer to the following: J.A.L. Waddell, Bridge Engineering, vol. 1 (New York: John Wiley and Sons, Inc., 1916), 25, 31-34; Carl W. Condit, American Building: Materials and Techniques from the First Colonial Settlements to the Present, 2nd edition (Chicago and London: The University of Chicago Press, 1982), 145-146, 148-151; David Plowden, Bridges: The Spans of North America (New York: Viking Press, 1974; repr., New York and London: W.W. Norton and Company, 1984), 123-124; Francis E. Griggs, Jr., "Never a Way too Wide: the First 50 Years of Cantilever Bridge Construction," MS in preparation, 1993, 36-58.

In building the main truss by the cantilever method, Munster transformed the bridge's first three spans into what was essentially a single continuous truss. To leave the bridge in this state, however, was to court future problems, for continuous construction did not readily accommodate thermal expansion and contraction of its members, nor shifting in its substructure. Continuous spans were also "indeterminate," meaning that their internal stresses were extremely difficult to calculate.[46]

By the mid 1800s, engineers had determined that these problems could be resolved by inserting hinges into continuous spans. The hinges allowed the bridge to expand and contract while also accommodating minor changes in pier height. In addition, the hinges broke the continuous beam into a series of cantilevered and suspended spans, which engineers could easily analyze. A German engineer, Heinrich Gerber, was one of the first to design cantilevered truss bridges to overcome the problems inherent in continuous structures. He patented his truss design in 1866 and built the first example in 1867. In the United States, a number of continuous bridges with hinge points were designed in the 1860s, but none appears to have been built at that time. One of the first to be erected was the Kentucky River High Bridge in 1877. Built as a continuous truss to simplify erection by the cantilever method, the engineers inserted hinges, creating cantilevered spans, to break up the continuity once the truss was completed.

Drawing on this precedent, Munster placed two hinges in the Wabasha Street Bridge. He located one in the lower chord of the first span and the other in the top chord of the third span

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[46] For a discussion of continuous trusses and the use of hinges, refer to the following works: Condit, American Building: Materials and Techniques, 144-151; Henry J. Cowan, Science and Building: Structural and Environmental Design in the Nineteenth and the Twentieth Centuries (New York: John Wiley and Sons, 1978), 16-17; 51-52; Waddell, vol. 1, 482; Griggs, "Never a Way too Wide," 13-35; W. Westhofen, "The Forth Bridge," Engineering (28 February 1890): 217-219; "Cantilever Bridges," Railway Review (25 April 1896): 233-234; "Suspension and Cantilever Bridges," Engineer (17 January 1902): 62.

(see HAER Photo No. MN-75-11; MN-75-14). These hinged connections created short cantilevers: one extending 60 feet northward from the first pier, thus forming part of the first span; the other reaching 40 feet southward from the second pier, forming part of the third span. Beyond the cantilevers, the first and third spans were composed of simple suspended trusses. In other words, for the first span, a 65-foot truss lay between the north cantilever and the north abutment. One end of the truss rested on the abutment, while the other end hung from the cantilever. The third span featured a 150-foot suspended truss: one end attached to the cantilever and the other resting on the third pier. Through this arrangement of suspended spans, cantilevers, and continuous trusses, Munster created three clear spans of 125 feet, 280 feet, and 190 feet, proceeding from north to south (see HAER Photo No. MN-75-10; MN-75-12; MN-75-13).[47]

Munster realized that hinges alone could not fully compensate for the expansion and contraction of truss members. He therefore placed a movable bearing on the north abutment and designed the piers on either side of the river as rocker bents. Constructed of steel on stone pedestals, the bents were attached to the trusses by means of moveable bearings (see HAER Photo No. MN-75-22; MN-75-24). Munster was also apparently aware that cantilever spans were prone to excessive sway and vibration, particularly in short spans. To dampen the movement, Munster used rivetted connections in the 65-foot suspended truss in the first span (see HAER Photo No. MN-75-11). Rivetted connections were more rigid than normal pinned

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[47] For a description of the layout of the bridge, see the following: "Erection of the Wabasha Street Bridge, St. Paul, Minn., Part I," 1891, 58 (note that the article misreports the length of the first span to be 135 feet); Grytbak, "Memo of Wabasha Street Bridge History." Also refer to the following plans held in the Bridge Division, St. Paul Public Works Department, St. Paul, Minnesota: "Wabasha St. Bridge, Proposed Plan of Rebuilding," n.d.; "Wabasha Street Bridge, 65 ft. Span," [c.1888]; "Wabasha Street Bridge, Cantilever Span," [c.1888]; "Wabasha Street Bridge, Detail of South Cantilever Arm," [c.1888]; "Wabasha Street Bridge, 150 ft. Span," [c.1888].

connections, and Munster apparently hoped that this would limit the vibrations in the short first span.[48]

While Munster's design was an ingenious solution to a complicated construction problem, it was not unusual or novel for its time period. As noted, the cantilever method had been used since the 1870s, and hinged, continuous bridges had been built since the mid-1860s. Indeed, both of these features had already been employed in the Fort Snelling Highway Bridge over the Mississippi, located only four miles upstream of the Wabasha Street Bridge. Horace E. Horton of Rochester, Minnesota, designed the cantilevered superstructure for this bridge and erected it by the cantilever method in 1880.[49]

Rundlett submitted Munster's plans for the Wabasha Street Bridge to the Common Council in August 1888. The city opened bids for the work in September and awarded the contract for the substructure to the local firm of McMullin and Morris. The Keystone Bridge Company of Pittsburgh, Pennsylvania, received the contract to fabricate the superstructure. Undoubtedly due to his experience with cantilever construction, Horace E. Horton won the contract to erect the bridge.[50]

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[48] Location of movable bearings is shown in Bureau of Bridges, Department of Public Works, "Wabasha Street Bridge, General Plan and Elevation," sheet 2, 30 June 1987, Bridge Number 6524, Active Files, Minnesota Department of Transportation, St. Paul, Minnesota.

[49] Maltby, "The Mississippi River Bridges," 430-432; "Fort Snelling Bridge, A Splendid Structure Costing, with Approaches, $134,925.80, Final Report of the Bridge Commission to the Board of County Commissioners, A Responsible Trust Faithfully Executed," St. Paul Daily Globe, 21 November 1881, 2:5; Griggs, "Never a Way too Wide," 77-80.

[50] See the following entries in the volume for 1888, St. Paul City Council Minutes: 21 August 1888, 422; 11 September 1888, 466-467; 18 September 1888, 482. Also see Maltby, "The Mississippi River Bridges." Born in New York State in 1843, Horace E. Horton moved to Rochester, Minnesota, with his family in the late 1850s. Horton returned to New York in 1863 to obtain an education in civil engineering at the Fairfield Seminary. Returning to Rochester in 1866, he worked as a surveyor and bridge builder. Most of Horton's bridges in the 1860s and early 1870s were small wooden structures. By the mid-1870s, however, he began building larger iron spans, including a bascule over the Chippewa River in Chippewa Falls, Wisconsin, in 1874, and the Fort Snelling Bridge,

Construction began during the winter of 1888-1889. As planned by Munster, Horton built the first and third spans on falsework, while he erected the center span partially by suspending it from the old wrought-iron truss and partially by the cantilever method. Workmen raised material for the central portion of the span into position from barges located in the river channel below. Rundlett later observed that the hardest part of the project proved to be placing the floor beams into position around the web members of the old truss, as each was 60 feet in length and weighed as much as 10 tons. Once the superstructure had been completed, the contractors disassembled the old bridge trusses and substructure. McMullen and Morris removed all of the masonry from the original piers, leaving only the supporting piles in the river bed. No serious delays appear to have occurred, and the contractors completed all work by the spring of 1889. The costs of the substructure and superstructure were, respectively, $56,527 and $102,156 (for detailed construction plans, refer to HAER Photo No. MN-75-30 to MN-75-49).[51]

In 1892, the St. Paul City Engineer's Office prepared tentative plans to rebuild the remainder of the Wabasha Street Bridge. At that time, the south half of the structure consisted of seven spans: four 140-foot deck trusses, one 110-foot deck truss, and two through truss approaches, all dating from the previous decade. The City Engineer's Office proposed building an earthen causeway to replace the two through-truss approach spans. The rest of the south half

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started in 1878 and completed in 1880. Horton expanded his bridge building activities in the 1880s, becoming a major regional builder, active throughout Minnesota, Wisconsin, and Iowa. In 1889, Horton founded the Chicago Bridge and Iron Company. He closed his practice at Rochester a few years later. For biographical information on Horton, refer to Eli Woodruff Imberman, "The Formative Years of Chicago Bridge and Iron Company," Ph.D. dissertation, University of Chicago, 1973. Also see Victor C. Darnell, <u>Directory of American Bridge-Building Companies, 1840-1900</u> (Washington, D.C.: Society for Industrial Archeology, 1984), 11, 29.

[51] "Erection of the Wabasha Street, St. Paul, Minn," Parts I and II; "Specifications for Substructure of the Wabasha Street Bridge Across the Mississippi River," January 1889, St. Paul Public Works Correspondence Files; <u>Annual Reports of the City Officers and City Board of the City of St. Paul, 1888</u> (St. Paul: Globe Job Office, D. Ramaley and Sons, Printers, 1889), 549-557; Grytbak, "Memo of Wabasha Street Bridge History."

would be replaced by five spans: three simple deck trusses and one deck truss with a cantilever that would serve as an approach span (see HAER Photo No. MN-75-50). Probably due to funding shortages, the city delayed the work for several years. In October 1898, Munster finally resharpened his pencil and once again prepared plans and estimates for the south half of the bridge. Abandoning the earlier scheme, Munster decided to replace the southern seven spans of the bridge with three Pratt deck trusses and one steel plate-girder approach span. As before, he planned to extend the earthen causeway on the west shore to replace the two approach spans (see HAER Photo No. MN-75-31).[52]

The City Engineer submitted Munster's plans to the city government in March 1899. The Committee on Streets approved the design in April, and the city opened bids for all work in May. The first phase of the project was to build a temporary bridge to carry traffic during construction, and the city awarded this contract to William S. Hewett, a Minneapolis bridge builder. Charles Stone, a local contractor, and J.G. Wagner, a Milwaukee bridge builder, were the successful bidders for the substructure and superstructure, respectively.[53]

Hewett began erecting the temporary bridge in July 1899. Following a scheme of work

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[52] For descriptions of the south half of the bridge, refer to the following plans in Bridge Division, St. Paul Public Works Department: City Engineer's Office, "Wabasha Street Bridge, Skeleton Plan of Present Bridge, Proposed Plan of Rebuilding," July 1892; "Wabasha St. Bridge, Spans I, II, and III," 1900; "Wabasha St. Bridge, Span IV," 1900. For the redesign of the bridge in 1899, see Book 3, Bridge Maintenance Books, Bridge Division, St. Paul Public Works Department, St. Paul, Minnesota, 136.

[53] Refer to the following entries in volume for 1898-1900, St. Paul City Council, Minutes for the Board of Aldermen, State Archives, Minnesota Historical Society, St. Paul, Minnesota (collection hereafter referred to as "St. Paul Board of Aldermen Minutes"): 21 March 1899, 475; 4 April 1899, 510; 2 May 1899, 519. Also refer to the following entries in St. Paul City Council, Assembly Journals, State Archives, Minnesota Historical Society, St. Paul, Minnesota (collection hereafter referred to as "St. Paul Assembly Minutes"): 4 May 1899, volume for May to September 1899, 47; 21 September 1899, volume for September 1899 to May 1900, 47-48. Organized in 1895, the J.G. Wagner Company was the successor firm to the Milwaukee Bridge and Iron Works, first founded in 1875. Wagner continued in business until being absorbed by the American Bridge Company in 1900; see Darnell, "Directory of American Bridge-Building Companies," 74.

developed with Munster, Hewett first constructed temporary timber piers for the bridge 50 feet downstream from the Wabasha Street Bridge. Using skids erected on pile bents, he then pushed the three southernmost 140-foot trusses of the existing bridge to the temporary piers. A trestle connected the temporary bridge to the west shore. After dismantling the remaining four spans, Hewett delivered them to a nearby city storage compound so that they would be available for subsequent reuse. The contractor opened the temporary bridge to travel in mid-November at a total cost of $7,191.54.[54]

Once Hewett had removed the old trusses, Stone immediately began disassembling the original masonry piers of the Wabasha Street Bridge. Stone then constructed a two-legged pier on Navy Island, a solid pier in the west-shore river channel, and another two-legged pier on the west shore. He also constructed a new south abutment, as well as an earthen embankment along Wabasha Street leading to the south approach (see HAER Photo No. MN-75-25 to MN-75-28). Stone took slightly more than the eight months allowed by his contract to complete the substructure and causeway, and Munster noted in his journal that the contractor "commenced

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[54] Untitled ledger, Bridge Maintenance Books, Bridge Division, St. Paul Public Works Department, St. Paul, Minnesota, 136-137, 147; A.W. Munster, "Temporary Bridge Across the Mississippi River at St. Paul, Minnesota, Moving of Three 140-foot Spans," Association of Engineering Societies (St. Louis) (January 1900): 58-61; "Specifications for Construction of Wooden Piers and Trestle Bridge and Moving and Taking Down Old Iron Spans," n.d., St. Paul Public Works Correspondence Files. William S. Hewett was born in Maine in 1864. After receiving a normal school education, he moved to Minneapolis in 1887 to take a job with his uncle, Seth Maurice Hewett, who had been operating a bridge building company in Minneapolis for several years. William founded his own bridge company in 1897, having spent the intervening time learning the trade from his uncle. William's company was extremely successful, and he constructed bridges throughout Minnesota, the Dakotas, and Montana. In later years, he became noted for his work in prestressed concrete, developing a system for building water tanks and domes. For information on Hewett, refer to the following sources: William Sherman Hewett, "A Biography," Typewritten MS, n.d., State Archives, Minnesota Historical Society, St. Paul, Minnesota; Frederic L. Quivik, "Montana's Minneapolis Bridge Builders," IA: The Journal of the Society for Industrial Archeology 10, 1 (1984): 35-54.

work and prosecuted it in [a] desultory manner."[55]

Wagner began erecting the superstructure in July 1900. Following Munster's instructions, he began with the southernmost span and worked northward, "leaving the connection with the present bridge to the last" so as not to interfere with traffic on the temporary bridge.[56] As specified, Wagner erected three identical, 170-foot, pin-connected, steel Pratt deck trusses. The southern approach span was a 78-foot steel girder (see HAER Photo No. MN-75-17; MN-75-19). None of these spans was located over a navigable channel, and falsework therefore was permitted in their erection. Once completed, the new south section of the bridge featured a 36-foot-wide roadway flanked by 10-foot-wide sidewalks. The bridge deck consisted of brick paving over a wooden floor. The structure reopened to travel in August 1900.

The cost of replacing the substructure totalled $55,189, while work on the superstructure amounted to $96,880 (for detailed construction plans, refer to HAER Photo No. MN-75-51 to MN-75-58).[57]

Use of the Wabasha Street Bridge in the Twentieth Century

Although the Wabasha Street Bridge had been under almost constant reconstruction since 1859, it was to remain virtually unchanged for nearly a century after 1900. During this time, the crossing continued to serve as an important transportation artery linking downtown St. Paul with the West Side. The structure carried two lanes of traffic as well as, until the 1940s, tracks

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[55] Quote is from untitled ledger, Bridge Maintenance Books, 136. Also see "Specification for the Substructure of New Work," 15 May 1899, St. Paul Public Works Correspondence Files.

[56] "Specifications for the Superstructure," 26 July 1899, St. Paul Public Works Correspondence Files.

[57] Untitled ledger, Bridge Maintenance Books, 136-137; Grytbak, "Memo of History of the Wabasha Street Bridge."

for an electric railway. The railway connected West Side neighborhoods with the central business district, allowing residents to commute to and from work. The bridge also became a major thoroughfare for automobile traffic in the twentieth century, eventually becoming part of US Highway 52 and State Highways 13, 55, 56, 88, and 218. The bridge proved to be particularly important as a truck route, being one of only two structures leading into downtown capable of supporting the weight of these vehicles.[58]

The city made a number of minor changes to the bridge during the 1900s. In 1903, the City Assembly approved a measure to build a stairway from Navy Island to the bridge. The Minnesota Boat Club had built a similar stairway in 1873 to more easily reach its clubhouse on the island. The city apparently removed this structure when it replaced the south half of the bridge in 1899-1900. The new stairway was located on the west side of the fourth span (see HAER Photo No. MN-75-30).[59] More significant alterations became necessary as motorized traffic increased in the 1920s. At that time, trucks using the bridge were considerably heavier than earlier horse-drawn wagons, prompting the city to strengthen the bridge deck by placing cover plates on the floor beams and stringers. The engineer's office reinforced the four northern spans in 1924, and completed the remainder of the bridge in 1928.[60]

Aside from minor repairs and maintenance, the Wabasha Street Bridge stood unchanged until 1955. For several years, however, city engineers had observed that many floor beams and

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[58] "Application for Highway Project," October 1942, St. Paul Public Works Correspondence Files; City Planning Board, Plan of St. Paul (St. Paul: Commission of Public Works, 1922), 51.

[59] Regarding the 1903 stairway, refer to Index of Council File Numbers, 1900-1960, St. Paul Public Works Correspondence Files. For information on the earlier stairway, refer to Petition of the Minnesota Boat Club to City Council, 6 October 1873, St. Paul City Council Miscellaneous Records.

[60] Maurice W. Hewett to Lawrence M. Feirer, 4 September 1945; M.S. Grytbak to George M. Shepard, 14 October 1941, 16 January 1952; all in St. Paul Public Works Correspondence Files.

stringers were badly rusted and that the 36-foot-wide roadway was too narrow for current traffic. St. Paul therefore advertised for bids in February, 1955 to rebuild the deck. Because the bridge carried a state trunk highway, the Minnesota State Highway Department agreed to pay all costs for repair of the roadway and its supporting members. The Whiting-Turner Contracting Company of St. Paul won the contract for the work. The company replaced the existing paving and subflooring with a concrete and steel deck. Extra stringers were added, although the existing floorbeams apparently were not altered. As part of the work, the sidewalks were paved with concrete and narrowed to 8 feet in order to expand roadway width to 40 feet. The contractor also replaced the original bridge railings. With a wider roadway, the bridge carried two lanes of traffic in each direction.

After 1955 the Wabasha Street Bridge generally required only routine maintenance. Minor repairs included the replacement of worn rocker pins in the fourth pier bent in 1971, and the installation of a concrete apron in 1979, to protect the bluff on the east shore from erosion.[62] In spite of the bridge's trouble-free history, city authorities began to entertain the possibility that the structure would need to be replaced by the mid-1980s. While the Wabasha Street Bridge was structurally sound, it had a limited load capacity of only 18 tons for a single vehicle and 26 tons for a combined vehicle. By contrast, new bridges were generally designed

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[61] M.W. Hewett to St. Paul Street Railway Company, 23 October 1953; "Wabasha Bridge Repair Asked," newspaper clipping, 14 October 1953; Maurice W. Hewett to George M. Shepard, 14 August 1953; George M. Shepard to Frank D. Marzitelli, 11 October 1955; "Extraordinary Maintenance Agreement Between State of Minnesota and City of St. Paul, 21 January 1955; "Wabasha Bridge Will Be Rebuilt," newspaper clipping, 21 January 1955; M.W. Hewett to Twin City Testing Laboratory, 27 June 1955; all in St. Paul Public Works Correspondence Files. Also see M.W. Hewett, "Plans for New Deck and Repair of Wabasha Street Bridge," 14 January 1955, Bridge Division, St. Paul Public Works Department, St. Paul, Minnesota.

[62] Arthur Werthauser to Gene Butweiler, 6 December 1971; Donald E. Nygaard, "Summary of Engineering Recommendations," 20 April 1979; all in St. Paul Public Works Correspondence Files.

with a carrying capacity that was 50-percent greater.[63]

The matter came to a head in 1987. In the spring, St. Paul submitted plans to the Minnesota State Department of Transportation in order to receive federal funds for a variety of repair work on the Wabasha Street Bridge, including the rebuilding of expansion joints in the roadway, replacing bearing units, and repairing crumbling sidewalk concrete. While the Transportation Commissioner eventually approved the work, he initially delayed funding out of concern that the bridge was becoming obsolete and would need to be replaced. To answer the Commissioner's concerns, municipal and state engineers carefully inspected the crossing. They determined that while the Wabasha Street Bridge was indeed capable of carrying its posted loads, no one could predict its remaining life span. Given the lengthy and time-consuming process of applying for federal aid, the city determined that it was better to initiate the procedure immediately rather than continue waiting for the bridge to show signs of failure.[64]

In 1988, St. Paul secured the services of Toltz, King, Duvall, Anderson and Associates (TKDA), a St. Paul engineering firm, to coordinate the replacement efforts. TKDA first studied whether the bridge could be reinforced to meet current load capacity standards. Test results

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[63] St. Paul's plans for the bridge's eventual replacement are clearly stated in Donald E. Nygaard to George Latimer, 21 July 1987, St. Paul Public Works Correspondence Files.

[64] Unless otherwise noted, the following material is in St. Paul Public Works Correspondence Files: Department of Public Works, "Construction Plan, Bridge Repair and Rehabilitation, Wabasha Street Bridge," 14 May 1987; Wayne Wangstad, "Wabasha Street Bridge Replacement Urged," St. Paul Pioneer Press Dispatch, 19 July 1987; Donald E. Nygaard to George Latimer, 21 July 1987; Don Ahern, "Wabasha Bridge Called Safe, But Inspection Is Set," St. Paul Pioneer Press Dispatch, 23 July 1987; Jim George, "Old Bridges Causing New Headaches," St. Paul Pioneer Press Dispatch, 2 August 1987; Joe Koenig to Art Werthauser, 3 August 1987; Tracy Moe, "Summary of Joint Inspection of Wabasha Street Bridge, No. 6524, Over Mississippi River," 1 October 1987; Arthur Werthauser, "Wabasha Street Bridge Report," 24 November 1987; Sean T. Kelly, "Old Wabasha Street Bridge is Shaken Up by Stress Tests," St. Paul Pioneer Press Dispatch, 12 October 1988.

indicated that this option was not feasible, necessitating replacement.[65] Because the Wabasha Street Bridge had been listed on the National Register of Historic Places for its role in the development of the city and for its cantilevered design, the City of St. Paul agreed to document the structure prior to demolition according to the standards of the Historic American Buildings Survey/Historic American Engineering Record.[66] This study is intended to fulfill that obligation. At the time of this writing, the structure is scheduled for replacement in 1995.

[65] See, for example, Jim Bellefeuille to Arthur Werthauser, 1 June 1989, St. Paul Public Works Correspondence Files.

[66] Memorandum of Agreement between the St. Paul Department of Public Works, St. Paul Heritage Preservation Commission, and the Advisory Council on Historic Preservation, January 1991, St. Paul Public Works Correspondence Files; Quivik, Frederic L., National Register of Historic Places Registration Form for the Wabasha Street Bridge, 1988, State Historic Preservation Office, Minnesota Historical Society.

["Erection of the Wabasha Street Bridge, St. Paul, Minn., Part I." Engineering Record 25 (26 December 1891): 58]

BUILDERS' AND CONTRACTORS' ENGINEERING AND PLANT.

No. CXXVIII.

(Continued from page 41.)

ERECTION OF THE WABASHA STREET BRIDGE, ST. PAUL, MINN.

PART I.—GENERAL PLAN AND ELEVATION OF OLD AND NEW BRIDGES, DESCRIPTION OF STRUCTURES AND CONDITIONS AND PLAN AND ELEVATIONS OF CHANNEL SPAN TRAVELER.

THE Wabasha Street highway bridge across the Mississippi River, at St. Paul, Minn., was partly replaced in 1889 by a cantilever structure, built by the Keystone Bridge Company, of Pittsburg, Pa., and erected by Horace E. Horton, C. E., then of Rochester, Minn., and now Chief Engineer of the Chicago Bridge Company. L. W. Rundlett, City Engineer, of St. Paul, Minn., says:

"Relative to the old bridge and the conditions that govern the adoption of the design for the new bridge I would state briefly as follows: The old structure, 1,524 feet long, had an 18-foot roadway and two 6-foot sidewalks. It became necessary to rebuild the 240-foot span over the main channel of the river as it was too light for the traffic. As the bridge was also on the line of one of the main thoroughfares, and did not have sufficient capacity to allow trotting on the bridge, it was finally decided to construct the new portion 56 feet wide, having a 36-foot roadway and two 10-foot sidewalks, and to rebuild as much as the appropriation would allow, with the intention of rebuilding the remaining part to the full width at some future day. As the masonry in the old piers was in poor condition and totally unfit to be extended to the length required for the width of the new portion, an entirely new design was made without regard to old heights or spans. The piers are built on pile foundation; the total amount of masonry and concrete is 2,700 cubic yards; the total cost of the substructure, $50,527; total weight of iron in the superstructure, 1,855,000 pounds; total cost of the superstructure, $102,156; total cost of bridge (new part), $158,-783. The detailed plans for the structure were made in this office."

Figure 1 is a plan, and Fig. 2 is an elevation, showing the locations and outlines of the old and new piers and trusses, the old being indicated by broken, and the new by full lines. The relative positions of the two structures were such as to enable the new one to be connected up without serious disturbance or much removal of the old one, or impairing its integrity, but its members did interfere seriously with handling those of the new one during erection, especially with placing the new floor beams, which were completely assembled and riveted in the shops, and were nearly 60 feet long, and weighed 10 tons each.

On account of the demand of the public of the city of St. Paul, it was necessary to erect this work in the least possible time; furthermore, the channel had to be kept open from pier 1 to pier D, in the interests of navigation, hence false works were not admissible for this distance of 210 feet. The problem in arranging for erection was to prepare for the rapid movement of material, and some scheme was necessary which would allow of carrying a part of the weight of the new material of the channel span on the old span, and a part by the cantilever arrangement of the new work, neither being able to do it alone. The new work was a cantilever with hinge points at C in the 135-foot span, and at X in the 187-foot span, hence it became necessary to prosecute the work from each end. The traveler was erected over and above the old bridge on a trestle at pier D, and traveled on top of the new work. This traveler took out the material of the old bridge at the same time the material of the new truss was being placed. The false works extended no further than from pier 3 to pier 2. The cantilever arrangement before referred to allowing a coupling of the new work from pier 2 to pier B, where bearing was obtained. From the other end of the bridge, false works were built from the end of the work to pier 1, upon which the span was erected with a simple derrick traveling on the floor of the bridge. In the meantime the traveler F had been erected on top of the old 240-foot span.

In coupling the new work, the pins at the points Y and Z in the top chord were not driven until the entire work was assembled. This precaution was taken to locate the shear as between the cantilever arrangement and the portion being carried by the old truss. Thus the new work between pier 1 and point Z was suspended as a cantilever, as was also that part overhanging pier B to point Y, and in no way connected with the old truss. The panels between Z and Y were directly suspended to and carried by the old truss. The fact that the new work was fixed at point I, and the rocker bent at I, made it possible to move

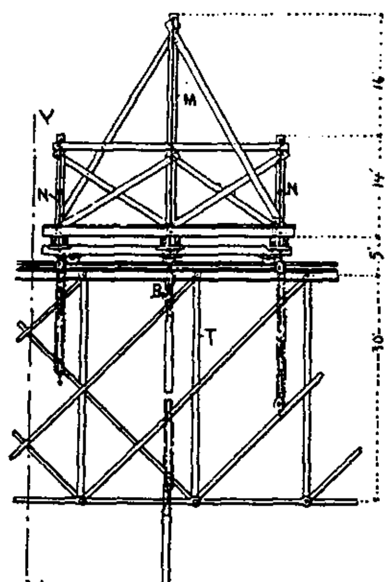

FIG. 4.

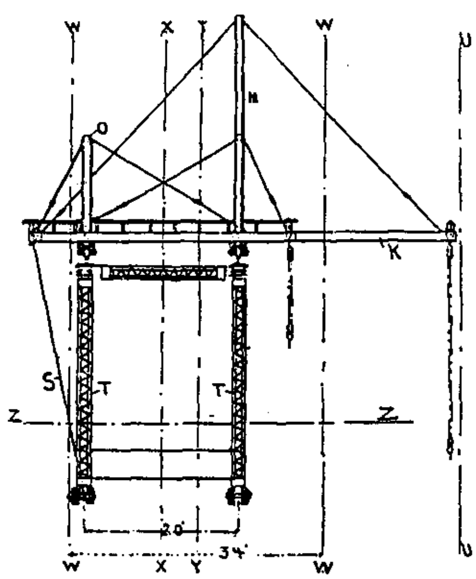

FIG. 5.

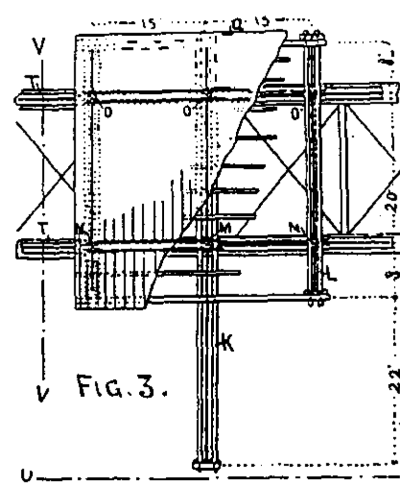

FIG. 3.

THE ENGINEERING RECORD.

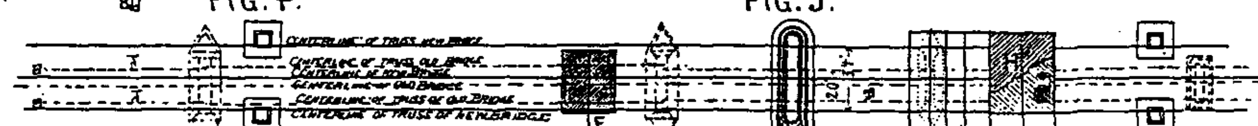

FIG. 1

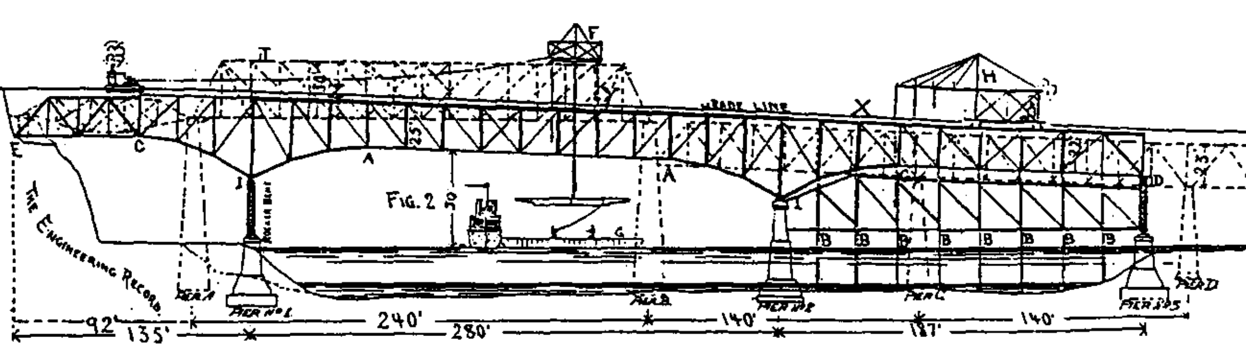

FIG. 2

ERECTION OF WABASHA STREET BRIDGE, ST. PAUL, MINN.

["Erection of the Wabasha Street Bridge, St. Paul, Minn., Part I." Engineering Record 25 (26 December 1891): 59]

the large mass of this work codways with very little difficulty in proportion to the quantity of material being moved. Forty days time was occupied from the time of the receipt of the metal for this work, until the bridge was open for traffic, and fully completed except the matter of painting. It will be noticed on Fig. 1 that the center line of the old bridge was not coincident with the center line of the new bridge by some 4 feet, hence before the traveler F had been erected on the 240-foot span it was necessary to move the old spans over transversely.

From sketches and explanations kindly furnished by Mr. Horton to a member of our staff, we have prepared in this office illustrations of the erecting travelers, designed and constructed for the special requirements of this case. These drawings are not absolutely to scale in details, but show design, construction, general features of arrangement, and operation, and sizes, and dimensions, accurately. The new structure from D to C, Fig. 2, was erected by traveler H, and sustained by trestle false work B B, etc., which also reinforced the old trusses. The trestling was continued to I, and the cantilever arm I C was built upon it, and being connected to the square span at C, sustained the channel arm I A, while it also was assembled from traveler H.

False-work trestles (not shown in Fig. 2), were set up, and sustained the other shore arms and truss J C E, which was assembled by an ordinary traveler, which consisted of a rolling platform, carrying hoisting engine and horizontal overhanging hoisting-beams. From Y to A the new bridge was erected by traveler F.

Figure 3 is a plan of traveler F., Figs. 1 and 2. Figure 4 is an elevation from U U, Figs. 3 and 5, and Fig. 5 is an elevation from V V, Figs. 3 and 4.

X X is the center line of the old bridge, Y Y is the center line of the new bridge, and W W are the center lines of the new trusses. Z Z is the center line of new truss top chord pins at one point, their position relative to the old bridge varying with the grade. The traveler carried one long overhang K and two short ones L L, trussed by king posts M and N, respectively. The traveler was anchored against overturning by the rods S, securely fastened to the old lower chord. The king posts O O O and truss rods were provided to meet the stresses from rods S S S. Material for the channel span was delivered on scows (G, Fig. 2) and hoisted from the overhangs L L, except the long and heavy floor beams, which were handled from overhang K. As these beams had to be swung clear of the old trusses and then inserted between their web members and lowered to position, the operation was difficult and apparently hazardous on account of moving so long and heavy a member so far eccentric from the base of support, and it was accomplished by hoisting the floor beam from the outer end of K, by means of one tackle and a center lashing (see Fig. 2). After the floor beam was raised to the old truss, another tackle was hitched from the middle of boom K to the same lashing, and by pulling and slacking on the two falls the floor beam was carried endwise through the old truss to a position directly above its final position, to which it was readily lowered, the interfering diagonals (if any), of the old trusses being temporarily disconnected for the purpose.

(To be continued.)

SOME DISPUTED POINTS IN RAILWAY BRIDGE DESIGNING.*

(Continued from page 27.)

TAKING up now the second division of "Group A," viz., "The Proper Live Loads for Modern Bridge Specifications," the writer would suggest the following classification for uniform train loads, preceded by two coupled engines that occupy a total length of 104 feet, and each have equal loads on each of four driving axles, and each of five small pairs of wheels, with spacings of 8 feet each between the engines, between each engine and tender, between each pilot and driver axle, 10 feet from rear tender axle to first train truck, 10 feet between train trucks, and 5 foot spaces at all other spaces:

Class.	Weight on each pair of Drivers.	Weight on each pair of Small Wheels.	Uniform train load per Lineal Foot.
Z	24,000 pounds.	15,000 pounds.	3,000 pounds.
Y	27,000 "	16,000 "	3,200 "
X	30,000 "	17,000 "	3,400 "
W	33,000 "	18,000 "	3,600 "
V	36,000 "	19,000 "	3,800 "
U	39,000 "	20,000 "	4,000 "

*From a paper presented to the American Society of Civil Engineers by J. A. L. Waddell, December 2, 1891.

Class Z, of this series, corresponds practically to Cooper's "Class A," and the Class U to his "Lehigh Heavy Grade Engines."

If we were to compare the moments found by Mr. Cooper's alternative live load for Class A, with those obtained from our previously found equivalent uniformly distributed loads *after their adjustment by the curve*, we would see that there is only one case where the former would exceed the latter, and that by only 1.4 per cent., hence it is reasonable to conclude that, for spans and panels exceeding 15 feet, the alternative load is unnecessary.

Passing to "Group B," which relates to "Wind Pressure," we will divide the subject into two parts—viz.: "Amounts" and "Effects." In respect to the former the practice has, of late years, changed somewhat, the tendency being to reduce the intensities specified and to provide more thoroughly for the effects. For instance, many of the older specifications called for a pressure of 50 pounds to the square foot of surface on both sides of the span, when the bridge is empty, while, in fact, nearly every structure designed by said specifications would double up like a jack-knife under such a pressure. In most of the modern specifications, instead of stating the amount of wind pressure per square foot of surface, the amount per lineal foot for each chord is given, that for the loaded chord being 450 pounds, and that for the unloaded chord 150 pounds. For short spans this method is all right, in that it prevents the use of too light lateral rods and struts, but for long spans the amounts are too small. In the writer's opinion the best specification for wind pressure would embody both methods, using the standard 600 pounds as a minimum, and calling for intensities on the empty structures varying between 40 pounds for very short spans and viaducts and 25 pounds for very long spans, those on the loaded structures varying from 30 to 25 pounds.

In respect to areas opposed to wind pressure, it is the writer's practice to double the area of the vertical projection of one truss, deduct therefrom the area of the leeward web protected by the train, and add to the difference the area of the floor system found by multiplying the span length by the vertical distance from the top of the guard rail to the bottom of the stringer. If the lower lateral diagonals be not protected by the windward chord or by the stringers, their area is to be included also.

In good practice the effects of the wind loads are followed from the points of application until the masonry is reached, and both the direct and indirect effects are considered. By direct effects are meant stresses which come directly from the loads, such, for instance, as the tension on the leeward bottom chord from the loads of the lower lateral system. By indirect effects are meant those which do not come so directly (and are, therefore, too often ignored), such, for instance, as the increase in the tension of the leeward bottom chord due to the load that is transferred from the windward to the leeward side in resisting the overturning moment of the wind loads of the upper lateral system, or the somewhat complicated wind stresses in the inclined end posts of through bridges

The amounts for the transferred load stresses cannot be determined with accuracy, but as they are large it is not proper to ignore them for such a reason; because by making certain assumptions they can be found approximately.

As in general, the upper lateral system has, or ought to have, much more rigidity than the overhead transverse bracing, the probability is that most of the upper wind loads will travel by the former: so certain engineers, and of late, among others, the writer, have been in the habit of assuming for convenience that they travel entirely in that way, and that in consequence the stresses from transferred loads in both leeward and windward bottom chords are constant from end to end of span, provided the top and bottom chords be parallel.

The released loads on the windward pedestals cause a decrease in the dead load tensions of the windward bottom chord, and this effect should be added invariably to the compressions in said chord from the wind loads of the lower lateral system when testing for reversing bottom chord stresses with empty structure.

We will now pass to "Group C," viz., "Styles and Proportions of Bridges." Experience has shown that for spans up to 90 or 100 feet, plate girders are the proper thing to use. They should, however, be built in one piece at the shops, and never spliced in the field. This will limit the span for such structures to three car lengths.

On account of the unavoidable uncertainty concerning stress distribution that exists in riveted connections, plate girders, whenever they can be used, are preferable to lattice girders. The latter, however, as through bridges, for single-track spans between 100 feet and 150 feet in length, and for double track spans between 100 feet and 125 feet, are the proper style of structure to adopt. However, they should invariably be built upon the single cancellation principle instead of, as ordinarily, with several systems of intersection. The writer would rule out entirely the pony truss bridge because of the uncertainty in computing the strength of the top chord. In the first place, its length as a strut, is indeterminate; and in the second place, the side bracing, when attached to shallow floor beams, is liable to do more harm than good by forcing the panel points of the top chord out of line.

For spans exceeding 150 feet for single-track bridges, and 125 feet for double-track bridges, the Pratt truss with its vertical intermediate and inclined end posts has proved to be the most satisfactory structure.

Beyond the limit of about 250 feet (more or less according to the lightness or heaviness of the load carried), it is well to economize metal by adopting what is termed by some engineers the "Pettit" truss and by others the "subdivided Pratt truss," inclining the top chord as may seem advisable—in fact, the top chord may be inclined or broken to advantage in Pratt truss spans exceeding, say, 175 or 200 feet. In the Pettit truss the writer has become convinced that, in dividing the panels, it is much better to carry the intermediate panel load by a strut towards the pier than to take it by a tie towards the center of the span.

The inclination of the top chord to the horizontal is a feature that can be and is sometimes carried to excess. Its effect is, undoubtedly, to economize in metal; but at the same time its excessive use will throw too much work upon the top chord and leave very little to be done by the web, which, therefore, becomes light and vibratory. Again, with excessive curvature of top chord, the stresses in web diagonals are liable to reverse.

The proper minimum distance between central planes of trusses for long through spans is still an undetermined point, some engineers making it one-twentieth and others one-eighteenth of the span. The writer is now inclined to adopt a middle course by calling it one-nineteenth of the span, although he once designed some 500 feet spans with a perpendicular distance between trusses of 25 feet. It is hoped that those engineers who think that the smaller limit will induce too much vibration, will, in the discussion of this paper, give their reasons for so thinking. In case of deck structures either the limit for the perpendicular distance will have to be increased or the truss depth will have to be decreased in comparison with the same dimensions for through bridges on account of the greater overturning moment of the wind pressure; and for through spans of medium length, say 250 feet, the perpendicular distance between central planes of trusses should be much more than one-nineteenth of the span. The writer would suggest the following table for through spans of railway bridges:

Span.	Least Perpendicular Distance between Centers of Trusses.
250 feet and under.	18 feet.
300 " "	19 "
350 " "	21 "
400 " "	23 "
450 " "	25 "
500 " "	27 "
550 " "	29 "
600 " "	31 "

The writer is an earnest advocate of the increasing of clear roadways from 14 to 16 feet for single track through bridges, and from 27 to 29 feet for double track through bridges. The extra 2 feet of width thus gained, together with a properly designed floor system and efficient protection and re-railing apparatus at each end of the bridge, would do away with fully 90 per cent. of the bridge accidents caused by derailments, and thus deprive the opponents of pin-connected bridges of their sole argument that is worthy of consideration.

The maximum allowable truss depth, except for deck bridges, should never exceed three times the perpendicular distance between central planes of trusses; and when the extreme depth is used at mid-span it should be reduced towards the ends considerably. In important bridges the lower lateral systems should be rigid. Long panels for wide bridges are all right, but for single track spans of short and medium lengths, extraordinarily long panels cause the lateral diagonals to act with too small an inclination to the planes of the trusses, and thus lessen their power to check vibration.

The writer proportions the width of eye-bars according to their length, from 2 inches for 15 feet to 10 inches for 40 feet.

For several years the writer has adopted the following floor system: metal stringers spaced 8 feet centers; pine ties, 8x12 inches on edge, and dapped 1 inch on to stringers, each tie being bolted at each end through the stringer flanges and outer guard timbers with ¾-inch bolts staggered in respect to the flange angles; outer guard timbers, 6x10 inches, or 8x10 inches, dapped 2 inches on to ties, which are spaced, as nearly as may be, 13 inches centers, leaving openings of 5 inches, and inner guards either of 5x4x½-inch angle iron, or of 6x6-inch timber dapped 2 inches on to the ties, and faced on the sides next to the rails, with 3x3x½-inch angle iron, screw-bolted to the timber, the guard timbers being bolted to alternate ties with ¾-inch bolts.

(To be continued.)

FIRE HAZARDS FROM ELECTRICITY.

(Concluded from page 17.)

THE form of apparatus is fourfold in its nature: *First*, the ordinary serrated lightning arrester, which is generally able to protect the system by reason of the extent to which the lightning is divided by the numerous wires in its course.

Second, the telephones are protected against currents originating from incandescent lighting or power circuits; by means of pieces of easily fusible wire, about four inches in length, inserted in the line of the telephone system. A similar device consists of a strip of tinfoil rolled up with asbestos paper and forming a part of the circuit, the tinfoil being instantly vaporized by an abnormal current.

Third, for protection against the currents proceeding from arc lighting apparatus and those used for the transmission of power, particularly the overhead trolley system, the most efficient means has been the air cut-out, consisting of two pieces of gas carbon separated a very short dis-

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